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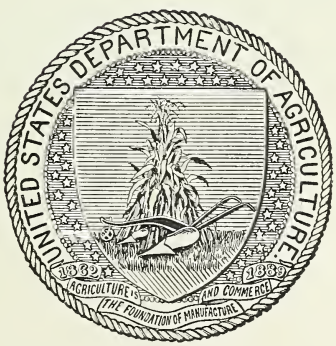
U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 202.
B. T. GALLOWAY, *Chief of Bureau.*

# THE SEEDLING-INARCH AND NURSE-PLANT METHODS OF PROPAGATION.

BY

GEORGE W. OLIVER, Plant Propagator.

Issued March 11, 1911.

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# LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
*Washington, D. C., September 20, 1910.*

Sir: I have the honor to transmit herewith a manuscript entitled "The Seedling-Inarch and Nurse-Plant Methods of Propagation," by Mr. George W. Oliver, Plant Propagator of this Bureau, and recommend that it be published as Bulletin No. 202 of the Bureau series.

Respectfully,

Wm. A. Taylor,
*Acting Chief of Bureau.*

Hon. James Wilson,
*Secretary of Agriculture.*

# INTRODUCTORY NOTE.

One of the most important factors in the creation of a plant industry which depends upon a perennial species is the rapid propagation of the plant. The possibility of bringing through the mails from any part of the world a few seeds of some rare plant is of relatively little moment if it is not backed up by adequate methods of quick reproduction from these few seeds through asexual propagation in order to produce large numbers of individuals for experimental trial. One of the greatest drawbacks of horticulture is the time required to test a new variety originated from seed, and any method which shortens the time required to make such tests must appeal to everyone, whether an originator of new varieties or a tester of them, as of the greatest value.

The seedling-inarch method which has been worked out by Mr. Oliver it is believed is destined to prove of the greatest importance not only in connection with the propagation of the tropical and subtropical fruits and ornamental plants with which this bulletin particularly deals (because it has been in his studies with them that he has come to realize its value), but in a very wide range of plant industries in which the early fruiting of a variety is very desirable. This shortening by a year or more of the time required for the fruiting of a new variety is believed to be a matter of such unusual importance as to be worthy of the widest publicity among all interested in the cultivation of plants. The discussion embodied in this bulletin, while it indicates the present stage of our studies of certain tropical-fruit industries, must be considered as having a much more general application than to these few new-fruit possibilities which are as yet little known to the American public.

David Fairchild,
*Agricultural Explorer in Charge of*
*Foreign Seed and Plant Introduction.*

# CONTENTS.


| | Page. |
|---|---|
| Introduction | 9 |
| Inarching rose seedlings | 11 |
| Propagation of the finger lime | 13 |
| The seedling-inarch method applicable to new plant introductions | 14 |
| Propagating the mango | 14 |
| Selecting and preparing the seeds | 14 |
| Soil for sprouting the seeds | 15 |
| Raising seedling stocks | 15 |
| Preparation of seedlings previous to inarching | 16 |
| The convenient placing of mother plants for inarching | 17 |
| Making the inarch | 20 |
| Watering seedling stocks while uniting | 20 |
| Treatment of the inarches before severing from the parent tree | 21 |
| Treatment of inarched plants | 21 |
| Testing the numerous varieties of the Indian and other mangos in Florida | 22 |
| Propagating the mangosteen | 23 |
| General statement | 23 |
| Difficulty in growing the mangosteen from seeds | 25 |
| Care of mangosteen seedlings while growing in pots | 26 |
| The root system of the mangosteen compared with other species of Garcinia | 26 |
| Propagation by the ordinary method of inarching | 27 |
| Condition of the wood of seedling mangosteens | 27 |
| Stock plants for the mangosteen | 27 |
| Growing seedling stocks | 29 |
| Preparing seedlings for inarching | 29 |
| Making the inarch | 30 |
| Removing the tops of the stocks and the roots of seedling mangosteens after a union has been effected | 31 |
| Inarched mangosteen seedlings reestablishing their own root systems | 31 |
| The nurse-plant system of propagating the mangosteen | 32 |
| Future stages of growth | 34 |
| Packing seeds for shipment | 34 |
| Preliminary treatment and sowing of the seeds | 35 |
| Propagating varieties of litchi by the seedling-inarch method | 36 |
| Propagating the rambutan | 38 |
| Summary | 38 |
| Description of plates | 40 |
| Index | 41 |

# ILLUSTRATIONS.

## PLATES.


Page.

PLATE I. Fig. 1.—Citrus australasica bearing fruit two years after the germination of the seed. Fig. 2.—Citrus australasica × C. mitis, grown from fruit shown in figure 1 ..... 40

II. Mango seed with eight sprouts ..... 40

III. Fig. 1.—Mango seedling attached to tree, showing cuts in stems of scion and seedling. Fig. 2.—Mango seedling and scion in place ..... 40

IV. Fig. 1.—Inarched mango after being severed from parent tree. Fig. 2.—Newly inarched mango in pot ..... 40

V. Fig. 1.—Mulgoba mango growing at Mangonia, Fla. Fig. 2.—Bench of newly inarched mangos ..... 40

VI. Fig. 1.—Sickly mangosteen restored to health by inarching. Fig. 2.—Inarching the mangosteen by the nurse-plant method ..... 40

VII. Mangosteen seedling inarched to Garcinia tinctoria, nurse plant .. 40

VIII. Fig. 1.—Inarched mangosteen reestablishing its own root system. Fig. 2.—Mangosteen developing root after inarching ..... 40

IX. Fruiting branch of the litchi (*Litchi chinensis*) ..... 40


## TEXT FIGURES.


FIG. 1. Rose seedlings, a cross between two varieties, four weeks after germination ..... 12

2. The rose seedlings shown in figure 1 four weeks after germination, prepared for inarching ..... 12

3. Rose seedlings, four weeks after germination, inarched to stocks of the manetti rose ..... 13

4. Inarched rose seedling, showing the growth made in two months after inarching ..... 14

5. Seedling of the finger lime (*Citrus australasica*) five weeks old, inarched to a 2-year-old lemon stock ..... 15

6. The same plant of the finger lime shown in figure 5 thirty days later .. 16

7. Seedling mangos four months old in 4-inch pots ..... 17

8. Seedling mango stocks prepared for inarching ..... 18

9. Branch of mango with 11 shoots inarched to seedlings ..... 19

10. Illustration of very old methods of budding used on the mango in Florida and elsewhere ..... 22

11. Fruiting branch of the mangosteen ..... 24

12. Mangosteen fruits cut open, showing the white edible interior ..... 25

13. Mangosteen seedling inarched on Garcinia tinctoria with foliage of stock plant opposite and below the union ..... 28

14. Group of mangosteen seedlings inarched by the nurse-plant method .. 33

15. Group of inarched litchi plants; also seedling litchi stocks prepared for inarching ..... 36

B. P. I.—617.

# THE SEEDLING-INARCH AND NURSE-PLANT METHODS OF PROPAGATION.

## INTRODUCTION.

While investigating the asexual propagation of some tropical fruit trees and other plants, at the request of Dr. B. T. Galloway, Chief of the Bureau of Plant Industry, it was discovered by the writer that a large number of hard-wooded shrubs and trees are capable of very rapid increase when propagated by processes which may be termed the seedling-inarch and nurse-plant methods.

These methods are inexpensive and, owing to their simplicity, may be used by persons without previous experience in the propagation of plants. By these methods the ever-increasing number of plant breeders will be enabled to save much time in determining the value of hard-wooded plants raised by means of hybridization. They can be used in manipulating seedlings of rare trees and shrubs intended for crossing, so that each plant will bloom in a much shorter time than if left to grow on its own roots. Seedlings of all hard-wooded plants resulting from collections made by travelers in foreign countries may thus be brought to the flowering stage and their value determined quickly.

The most remarkable feature of the new methods lies not only in their simplicity but also in the certainty of the unions which result. The writer has had very few unsuccessful unions and none among those classes of plants where the most suitable stocks are known and in common use. Not only is it possible to inarch a seedling a few weeks old to a large stock, but a moderate-sized seedling stock can be inarched to a shoot of a rare shrub or tree having the same diameter as the stem of the seedling. A satisfactory union may thus be induced where other methods of asexual propagation have invariably failed.

Rose seedlings resulting from crossing varieties have been inarched on manetti stocks when the seedlings were from 3 to 4 weeks old, and they produced maximum-sized flowers long in advance of those on seedling plants growing on their own roots. The rare finger lime, *Citrus australasica*, sometimes seen in a dwarf, sickly condition in

greenhouse collections, has borne fruit in two years after inarching on one of its congeners; and within nine months after flowering, hybrid seedlings between this citrus and a cultivated orange were in their turn inarched on 2-year-old lemon seedlings.

Very young seedlings of hundreds of other rare hard-wooded plants may be worked on the same or allied species or genera and their value determined much in advance of the time when they would flower on their own roots or on plants obtained by grafting or budding from the mature shoots of the seedlings.

Hard-wooded seedlings which need to be flowered in the shortest possible space of time, in order to determine their value, are used for inarching as soon as the first leaves attain a fairly firm texture, as, for example, in the case of the mangosteen. But when seedlings are used as stocks for the vegetative propagation of established varieties by uniting the stocks to small branches, then larger seedlings are used, as, for example, in the case of the mango.

The cultivation of the mango on a large scale has been delayed by our hitherto expensive and clumsy methods of propagation. In a recent bulletin issued by the Commissioner of Agriculture for the West Indies[a] the cost of producing large numbers of the finer varieties of cacao plants by inarching the small branches of these varieties to seedlings grown in bamboo pots is given at 6 cents each. In places where the mother mango trees have already been grown and are available for such use the owner will find the cost per inarched plant by the method here given to be reasonably small because the mango is as easy to inarch as the cacao.

Since the introduction by the Bureau of Plant Industry of more than a hundred varieties of the mango from India and other parts of the world, the cultivation of this much-esteemed fruit in the semi-tropical parts of the United States and elsewhere is gradually assuming important proportions. The propagation of young trees of those varieties which have been tested must necessarily be accomplished by asexual methods, as the finer Indian varieties do not come true from seeds.

The methods of propagation up to the present time have all been more or less faulty and cumbersome. The budding of seedlings in nursery rows requires the services of a trained propagator who knows what to do and how and when to do it. The average cultivator can hardly hope to acquire the skill necessary for the operation; moreover, there is always danger of loss from transplanting budded seedlings. Propagation by the older method of inarching on plants growing in 5 and 6 inch pots, sometimes for more than a year, is an expensive

[a] Jones, J. The Grafting of Cacao. Dominica, 1909.

method, necessitating the erection of strong staging around the parent trees for the accommodation of the plants in pots; moreover, the roots of the seedlings become curled in the pots and make it difficult to develop a good root system for the future tree. The method here described has the advantage of being by far the easiest to use. Each grower may be his own propagator. With a helper to prepare the seedlings he can easily inarch several hundred plants in a day.

Many plants belonging to various genera have the reputation of being difficult to propagate asexually, but this is due mainly to lack of knowledge in regard to methods. The greater portion of those dicotyledonous plants considered to be difficult or impossible to propagate have this reputation because the methods successfully used on other plants have been applied and found ineffective. There are doubtless easy methods of asexual propagation for all hard-wooded dicotyledonous plants and even for some of the refractory monocotyledons.

The method described in the following pages appears to be the only one which has been successfully applied to the rarest and most prized of tropical fruit trees, the mangosteen. This is a fruit of high quality, and its cultivation on a large scale has been delayed principally by the difficulties encountered in its asexual propagation. Material for the work of propagation is somewhat difficult to obtain, but where an abundant supply is available seedling plants may be inarched with as little expense as with the young branches of the mango.

The method has also been very successful with rare varieties of the Chinese litchi, branches of these having been united with very small seedlings of common forms of the same species.

## INARCHING ROSE SEEDLINGS.

Seedlings of some of the rose groups resulting from crossing distinct varieties or otherwise take more than one season to produce flowers of maximum size to enable the breeder to judge of their merits. They take much longer to develop when budded on manetti or other stocks, because in that case a considerable time has to elapse before the growth of the seedling is strong enough to give buds and wood fit for propagation by budding or by grafting. Rose seedlings 3 to 4 weeks old, or after the first few character leaves are developed, lend themselves very readily to the seedling-inarch method of propagation. Tea and hybrid-tea seedling roses will give flowers of maximum size very quickly after the tiny seedlings are inarched to strong-growing manetti or other stocks, thereby saving much time in preliminary tests.

The operation of inarching is simplified if each seedling is pricked off into a 2-inch pot shortly after the cotyledons are developed. The

seedling should be placed as near the rim as possible (fig. 1). In two or three weeks the seedling makes sufficient growth to be removed from the pot, when a little fresh soil is held in place around the root

FIG. 1.—Rose seedlings, a cross between two varieties, four weeks after germination. Each seedling is grown close to the rim of a 2-inch pot so as to facilitate an easy approach to the stock plants when inarching.

FIG. 2.—The rose seedlings shown in figure 1 four weeks after germination, prepared for inarching.

by a piece of cloth about 5 inches square (fig. 2). The ball containing the roots of the seedling is secured to the stock, the stem of the seedling being placed close to it, so that the inarch may be easily accomplished

(fig. 3). The union is a rapid one and becomes perfect some time before the cotyledons decay.

It is well known that many seedling roses on their own roots produce flowers before the cotyledons decay, but the flowers are necessarily small and have little to indicate their eventual value. The seedling-inarch system shortens very considerably the period between germination and the production of flowers of maximum size—a material aid to the breeder in determining the value of the seedling within a few months after germination (fig. 4).

FIG. 3.—Rose seedlings, four weeks after germination, inarched to stocks of the manetti rose. During the process of uniting, the seedlings are kept in a moist and growing condition by the soil held around the union by burlap. A good union is effected in three to four weeks.

## PROPAGATION OF THE FINGER LIME.

To illustrate the possibilities of the seedling-inarch method, figures 5 and 6 show a seedling of the rare *Citrus australasica* five weeks after germination inarched on a 2-year-old lemon seedling. A branch of fruit from this inarched seedling is shown in Plate I, figure 1, as it appeared two years later. The two flowers which produced these fruits were fertilized with pollen from the flowers of a small orange tree. Thirteen seedlings resulted, and one of the seedlings from this cross, two years and eight months after the seed of the female parent tree was sown, is shown in Plate I, figure 2. All these seedlings in their turn, three weeks after germination, were successfully worked on seedling citrus stocks 1 to 3 years old, and in two more years these tiny inarched-seedling crosses are expected to bloom and produce fruit.

## THE SEEDLING-INARCH METHOD APPLICABLE TO NEW PLANT INTRODUCTIONS.

Seedlings raised from seeds of new and rare trees, shrubs, and vines may be induced to grow very quickly if used as scions when a few weeks old by inarching to strong-growing plants of other species of the same genus or in some cases on species of other genera of the same family. This has been done recently with such plants as chestnuts, walnuts, hawthorns, oaks, and many others. It is not necessarily done for the purpose of hastening the flowering or the fruiting of new plants, but to give quickly an abundance of material for propagation by budding or grafting when the new material is assumed to be valuable.

FIG. 4.—Inarched rose seedling, showing the growth made in two months after inarching. (One and one-fourth times natural size.)

If a hard-wood seedling of hybrid origin is tied to a large stock and they fail to unite, there is little or no danger of losing the seedling, provided its roots are kept damp during the period of making the attempt. If the inarch is not successful, the seedling can be repotted and grown in the usual way.

## PROPAGATING THE MANGO.

### SELECTING AND PREPARING THE SEEDS.

Seeds of the mango vary in size according to the variety, ranging from a little over an inch to several inches in length and from 1 to 2 inches or more in breadth. For producing stock plants good judgment should be used in procuring seeds from the fruits of healthy, vigorous trees, either cultivated or otherwise. The fruits should be gathered as soon as they are ripe on the tree, rejecting fallen and decaying fruits of either healthy or sickly trees. The seeds should be removed and cleared of the fruit pulp shortly after the fruit is ripe,

and washed to remove as much as possible of the pulp adhering to the fiber; otherwise rotting is likely to occur. Before sowing, the seeds should be allowed to become fairly dry on the surface.

### SOIL FOR SPROUTING THE SEEDS.

The best medium in which to germinate mango seeds is undoubtedly slightly decomposed coconut fiber, which after being used can be dried out and used again. The next best medium is good hammock soil, but any other material containing a large proportion of decomposed vegetable matter may be substituted.

The seed bed should be prepared in a sheltered place not too much exposed to the sun's rays and protected from heavy rains with hotbed sash, if necessary. Provision should be made whereby the water shed from the sash will not drain into the bed. Wooden flats about 4 inches deep and of convenient length and width for easy handling may be used in sprouting small lots of seeds.

FIG. 5.—Seedling of the finger lime (*Citrus australasica*) five weeks old, inarched to a 2-year-old lemon stock. The cloth is used to keep the soil in place around the roots of the seedling so as to sustain it during the process of uniting with the stock.

### RAISING SEEDLING STOCKS.

The seeds may be planted 2 or 3 inches apart and covered with about 1 inch of soil; they germinate freely within a few weeks if the seed bed is kept moist. A seed from an uncultivated tree in Florida usually produces several sprouts (Pl. II), but not all of them become strong plants. Seeds of some varieties procured from India and also from the Philippine Islands usually produce a single sprout. These plants make ideal stocks. When the first flush of leaves is fairly well matured the strongest plants may be separated from those that are weak and potted singly, each being given a 4-inch pot, or if

the pots are not available they may be placed in wooden receptacles not over 4 inches square and of the same depth.

When a seedling intended for use in inarching is potted or boxed, it should not be placed in the center of the receptacle. It will be found convenient and will cause less strain both on the stem of the seedling and on that of the shoot while the union is taking place if the stem of the seedling is near the edge of the pot or box (fig. 7). The seedling so placed when subsequently prepared for inarching may be united at a point an inch or so above the soil. The plants should be potted rather firmly in hammock soil of a nature similar to that used for germinating the seeds, with a small quantity of decomposed stable manure added. A space should be left between the top of the soil and the top of the pot, say three-fourths of an inch, so that for the time being a single watering will moisten the soil thoroughly.

FIG. 6.—The same plant of the finger lime shown in figure 5 thirty days later. At this stage the top of the stock and the root of the seedling are ready to be removed.

### PREPARATION OF SEEDLINGS PREVIOUS TO INARCHING.

In a few weeks some of the strongest of the seedlings will have made sufficient diameter of stem to be used as stocks for inarching. When the stem of the seedling reaches a diameter of a quarter of an inch and is fairly firm in texture (fig. 8), preparations for inarching may be commenced. The seedling is not inarched while in the pot, because even a 4-inch pot adds considerably to the weight (enough to make it impossible to tie it to the inarched branch); besides, its contents would dry out too quickly. Thick sacking cloth cut into pieces about 10 inches square is substituted for the pot. The seedling when removed from the pot is divested of that part of the soil, usually near the top, in which no roots have formed. The remaining

part of the ball is then given a protective covering of old coconut fiber or hammock soil, or if this is not convenient, chopped sphagnum moss, sand, and decomposed stable manure may be used. Part of the coconut fiber or other material is placed on the outstretched piece of sacking upon which the ball of the plant is then laid, and as the sacking is being brought up and around the ball additional soil is placed about the roots. Enough of this soil should be used to hold the moisture that is necessary while the seedling and branch are uniting. The sacking is then tied firmly with a piece of strong string and the plant is ready for working (fig. 8). This operation may be performed in about the time required to pot a seedling. Several hundred seedlings may be thus prepared at one time, and if the tree is not more than 4 or 5 feet in height every shoot may be inarched. (See fig. 9.)

FIG. 7.—Seedling mangos four months old in 4-inch pots. The stems of the stocks are about one-fourth inch in diameter. When potting, the seedlings are placed close to the rims of the pots to prevent strain on the stock and scion when inarching.

### THE CONVENIENT PLACING OF MOTHER PLANTS FOR INARCHING.

Most of the work of inarching on seedlings in large pots has hitherto been done in the field. Large and unwieldy platforms have been built around trees on which to place the potted seedlings convenient for inarching with small branches.

By the new method of inarching, this trouble and expense are unnecessary. The process of inarching and caring for the seedlings during the period of uniting will require much less work than by the older methods. Plants of tested and approved varieties intended for use in propagation can be kept from growing more than 5 or 6 feet in height. There is then no necessity for wooden staging, as the prepared seedlings weigh only about 1 pound each. A seedling in a 5-inch pot weighing nearly 4 pounds needs benching to support it, but the small seedlings tied in cloth can be supported by individual stakes or by a piece of string secured to a stout branch (fig. 9). The

use of large or even moderate-sized mango trees growing in the field with several feet of stem above ground for propagating purposes is inadvisable by the method herein described, because of the inconvenience entailed both in the operation of tying on the seedlings and in supplying them with water and shade during the time of uniting.

It would be a great saving of time and work if the trees to be propagated were planted moderately close together inside a lath structure,

FIG. 8.—Seedling mango stocks prepared for inarching. The topsoil, in which there are no roots, is removed, and additional soil or coconut fiber is placed around the ball and held in place with a piece of sacking. The seedlings are then ready to be inarched. Each plant when thus prepared weighs about 1 pound.

such as is used in many parts of Florida. This would not only give protection from the sun, but with the different desirable varieties contained in an inclosure of this nature, the work of caring for them would be reduced to a minimum. The trees could be kept dwarf, the seedlings put in place without inconvenience, and a large number of

seedlings attached to branches could be watered conveniently. Every small, ripened branch could be used for inarching, and in the case of tested and approved varieties the inarched seedlings could be planted out and kept as stock plants, to be used for inarching later on. It is entirely possible to grow a very large number of seedling-inarched plants within a few years, beginning with only a single plant in a 5-inch pot.

In Florida, mango trees of tested varieties have been grown into symmetrical specimens with many branches close to the ground, as

FIG. 9.—Branch of mango with 11 shoots inarched to seedlings. This branch is supported by a stout stake, which takes the place of the elaborate benching formerly used for the support of plants in large pots.

seen in Plate V, figure 1. When a tree of an approved variety has this habit, it is a simple matter to propagate enough young trees from it within two months to plant at least 10 acres of ground, and with a very small expenditure of money. Certainly with the material already at hand the cost per plant ready for setting out will be trifling.

### MAKING THE INARCH.

First select the branchlet to be inarched, taking care that the diameter of the stem is not greater than that of the seedling stock. It should be fairly well ripened and have several healthy leaves (Pl. III, fig. 1). Make a cut in the stem, beginning at a point 2 to 3 inches from the terminal bud (Pl. III, fig. 1, *A*); in taking a slice from the stem cut into the wood not more than one-third of its diameter. The slice removed may be about 2 inches in length; any leaves which hinder this operation should first be cut off. Make a cut of similar length and depth near the base of the stem of the seedling (Pl. III, fig. 1, *B*). Bring the stock and scion neatly together, the bark meeting on both sides if possible, and tie firmly with a piece of soft string or strand of raffia (Pl. III, fig. 2). After this is done it only remains to secure the ball of the seedling to the lower part of the branch; or if the inarched branch is a short one the ball may be tied to the older wood. It will often happen that the seedling will need no further support; but when necessary a cane stake for further tying may be utilized (fig. 9), or a strong cord may be fastened to a stout stake driven into the soil in a convenient position and the inarched seedlings attached to it. Many little devices of like nature will suggest themselves to suit the peculiarities of each mother tree on which it is desired to make inarches.

### WATERING SEEDLING STOCKS WHILE UNITING.

The process of uniting the seedlings to small branches of the mango trees will in no case be completed in less than four weeks; if the weather is cool it sometimes takes six weeks to effect a satisfactory union. It is very essential that the roots of the seedling be kept moist while the union is taking place. Under glass this is accomplished satisfactorily by the usual daily syringings, but out of doors, on large specimens, careful watching is absolutely necessary to prevent the seedling stocks from drying out at the roots. If the mother plants are growing within a lath structure, a syringing once or twice each day according to the weather will be all that is required. The seedlings should be often examined to ascertain their condition and supply their wants in this respect. While the stems are uniting with the branches the roots of the seedlings, if surrounded with such material as coconut fiber, will not dry out any more quickly than they would under the conditions accompanying the old method of inarching branches to large seedlings in pots.

The result of this method is to effect a perfect union. Staging for the support of large, potted seedlings is not necessary; there is absolutely no waste of material; and a much greater number of inarched plants can be grown in a given time, and much more cheaply, than by any of the older methods.

### TREATMENT OF THE INARCHES BEFORE SEVERING FROM THE PARENT TREE.

During the spring and summer months the unions will be in a satisfactory condition in from four to six weeks after the operation of inarching is performed. But the scions must not be severed from the parent tree all at once. Unless the separation is performed gradually, the check is too severe and may result in their collapse. By examining a few of the inarches about four weeks after they have been worked it will be readily ascertained if a union has taken place or if there is a likelihood of its being effected. When that stage is reached—that is, when the branch and the seedling seem fairly well united—the top part of the stock at the point immediately above the union and on the side opposite to it may be cut halfway through. A few days later the small branch united to the seedling at a point immediately below the union should be cut to one-third of its diameter; another cut may be given a few days later and the branch, together with the top of the seedling, may be entirely severed when a safe union is effected (Pl. IV, fig. 1). It should be understood that the time required for a satisfactory union depends upon several factors, such as the weather, condition of the scion, root condition of the stock, etc., but, as thousands of successfully inarched plants have shown, there is no danger of failure if the conditions be correct.

During the past three years many persons interested in the mango from southern Florida and from places abroad have visited the propagating houses of the Bureau of Plant Industry. Simple instructions to each visitor have enabled him to attach a seedling to a mango branch with not a single resulting failure.

### TREATMENT OF INARCHED PLANTS.

As soon as the inarched plants are severed from the parent tree they may be placed in a shaded frame for a few days before potting, to prevent wilting of the leaves. The atmosphere should be kept moderately moist, with the temperature not too high. The plants may then be prepared for potting by removing the string and burlap. Five-inch pots or shingle boxes 5 inches deep will be found large enough for most of the plants (Pl. IV, fig. 2). The soil will necessarily be that obtainable in the vicinity of the operations. Where loam is not available, hammock soil can be substituted, improved by adding finely chopped, old stable manure and using 1 part of this to 3 of the soil, ramming the mixture firmly around the original ball. Water is applied sparingly at first, but in sufficient quantity to keep the air moist around the plants, so as to encourage root growth. A deep frame facing north will supply the conditions necessary in this

respect. The water is best supplied to the plants by a watering can with sprinkling attachment.

As soon as the plants are established in their receptacles they should be gradually exposed to air and sunshine. Plants grown by this method (Pl. V, fig. 2), being worked immediately above the soil, can be safely sent long distances by mail. The Bureau of Plant Industry has successfully shipped inarched plants by mail to the Hawaiian Islands, and many hundreds have also been successfully sent by mail to experimenters in southern Florida.

## TESTING THE NUMEROUS VARIETIES OF THE INDIAN AND OTHER MANGOS IN FLORIDA.

Although nearly a hundred varieties of the mango are now growing in Florida and elsewhere, principally as a result of the seedling-

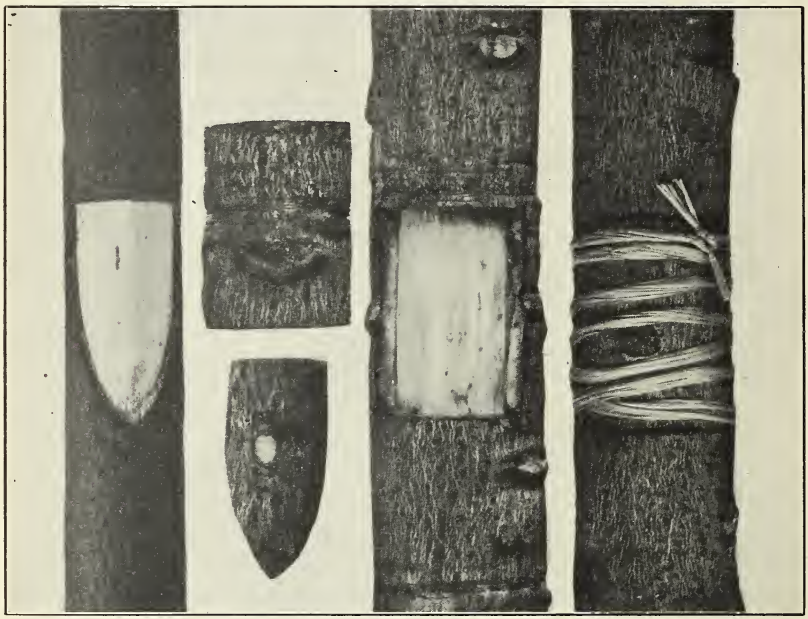


FIG. 10.—Illustration of very old methods of budding used on the mango in Florida and elsewhere. These methods involve a great waste of material. They are illustrated and described in Robert Sharrock's "History of the Propagation and Improvement of Vegetables," 1672.

inarch method, only about a dozen have fruited sufficiently to determine the quality of the fruit and its adaptability for the market. It is to be feared that many of these untested varieties are being increased irrespective of their merits. This is a mistaken policy and in many cases it may prove an expensive one. The aim of cultivators should rather be, in fruiting a variety the fruit of which is

unknown in Florida, to determine its worth before propagating it extensively. This may be done by using small seedling-inarched plants, after they have become established in 5-inch pots, for inarching on the old wood of stout branches.

After removing the plant from the pot, inclose the ball with soil kept in place with a piece of sacking and strong cord. Inarch the top of the plant to the thick part of a branch of a fruiting tree. Half a dozen or more distinct varieties may be placed on a single tree and carefully labeled. When the unions are secured, gradually remove the branch of the tree above the union, also the original inarched plant below the union, and coat the cut surfaces, especially that of the stock, with grafting wax so as to prevent decay. If the soil of the plants to be inarched is kept moist during the process of uniting the chances of failure are remote. The young inarched shoots will make rapid headway and will fruit much more quickly than young plants set out for testing. Two of the very old methods of budding, which are used on the mango in Florida and in other countries, are shown in figure 10.

## PROPAGATING THE MANGOSTEEN.

### GENERAL STATEMENT.

The mangosteen is one of the most remarkable of trees in that until lately it has defied attempts at asexual propagation. It has also the reputation of being the most difficult of all trees to grow. Most people who have sampled it pronounce it the most luscious of all tropical fruits (figs. 11 and 12).

The contention that the mangosteen is difficult to grow is abundantly proved in countries where it is cultivated and the high praise bestowed on the fruit is also well authenticated. The mangosteen is a native of the Malay Peninsula and Archipelago. It is cultivated in a small way in Ceylon, southern India, and Cochin China, and there are a few trees in the warmer islands of the West Indies, but nowhere is it cultivated to the same extent as other tropical fruit trees. It is doubtful whether more than a dozen fruiting trees can be found in the Western Hemisphere. Its requirements have probably not been understood here or elsewhere, as there is abundant evidence that it has time and again been planted in very unfriendly soils and under adverse climatic conditions. There is now little doubt that as a result of the successful experiments in its propagation in the greenhouses of the Department of Agriculture it will be possible to obtain healthy growth, especially where the mangosteen seedlings have been inarched on other species of Garcinia and also on other genera of the order to which the mangosteen belongs.

In the propagation of the mangosteen the method so successfully used with the mango, already described, is reversed. With the mango the seedling is used as the stock, but with the mangosteen the seedling is used as the scion. This would not be necessary if the shoots of the mangosteen tree were as easy to inarch as are the shoots of the mango. Two instances are recorded of attempts to propagate the mangosteen by inarching on other species of Garcinia.[a] In each instance the attempt at inarching seems to have been

FIG. 11.—Fruiting branch of the mangosteen. (From a painting by Miss D. G. Passmore.)

carried no further than to determine that a partial union took place between the stock and the scion. By a method similar to that used by Woodrow and Harris the writer was at first also unsuccessful.

The inarched trees recently planted in the Panama Canal Zone by the Bureau of Plant Industry have turned out well, and it is hoped that not only the proper method of propagation has been discovered, but also that a suitable place has been found where the mangosteen may be grown on a large scale and the fruit be more commonly seen in this country.

[a] See Woodrow, G. M., Gardening in India, 1888, p. 155, and Harris, W., Bulletin of the Botanical Department, Jamaica, no. 9, November, 1888, p. 3.

## DIFFICULTY IN GROWING THE MANGOSTEEN FROM SEEDS.

The cause of the difficulty in rearing young seedlings of the mangosteen has not been fully determined. Several experiments carried out from the gardener's standpoint to ascertain the cause have produced negative results. It is known that the most precarious period in the life of the mangosteen tree is the seedling stage, but even with seedlings the results of careful treatment are by no means uniform. When a comparatively large number are given the same soil, temperature, etc., all grow well until they are about 3 inches above the surface of the soil. After that period, when grown on their own roots, sometimes two-thirds of the number will either

FIG. 12.—Mangosteen fruits cut open, showing the white edible interior.

remain in a stunted condition or the leaves subsequently developed will have a yellowish-brown color.[a]

It seems to be the experience of cultivators in Ceylon, India, and the West Indies that when the leaves of a mangosteen seedling assume a sickly appearance there is little or no hope for the future health of the plant. This belief accords with the behavior of the

[a] "The mangosteen fruit seldom produces more than one or two seeds. These grow readily, but, so far as we are aware, few trees have been established from them. Our experience shows that after appearing above ground the seedling grows freely for one or two years, but afterwards generally assumes a sickly appearance and gradually dies out."—Bulletin of Miscellaneous Information, Royal Botanical Garden, Trinidad, January, 1895, vol. 2, no. 1, p. 10.

first lot of seedlings in the greenhouses of the Department of Agriculture. The roots of these sickly-looking specimens when examined superficially appeared fairly healthy, but whether at the beginning the trouble is with the roots or with the leaves has not yet been determined. It is known, however, that when the seedling depends on its own roots it is impossible to get those affected seedlings to develop healthy leaves above the sickly ones. The difficulty has been repeatedly overcome (in fact in every instance) when the sickly seedling is inarched to some strong-rooted species of the same genus.

Plate VI, figure 1, shows an inarched seedling mangosteen in which the two terminal leaves did not develop; furthermore, the leaves below the terminal ones died and after inarching all the growth above the first pair of leaves gradually succumbed, but the dormant buds lower down on the seedling developed the two healthy growths shown in the illustration (Pl. VI, fig. 1, *A*). It must not be inferred from this experience that this is the only method of propagating the mangosteen—or even a desirable method, for that matter. This point will be made clear in the description of the nurse-plant. method of propagation (p. 32).

### CARE OF MANGOSTEEN SEEDLINGS WHILE GROWING IN POTS.

Few plants show the results of inattention on the part of the cultivator more plainly than the mangosteen. When once a plant becomes in the least sickly, there is little likelihood of its recovery on its own roots. The mangosteen does not take kindly to heavy soils; it prefers a well-drained soil containing a large proportion of decayed vegetable matter. When seedlings are removed from flats and put in pots some will die without apparent cause. An oversupply of water causing the soil to become in the least sour is certain to induce sickness much more quickly in the mangosteen than in other species of the genus. Therefore, great care is necessary in handling the plants, especially in the early stages of the seedlings.

### THE ROOT SYSTEM OF THE MANGOSTEEN COMPARED WITH OTHER SPECIES OF GARCINIA.

Unfortunately the mangosteen is not a strong-rooting plant, especially during the first year or two after germination. This peculiarity renders it particularly sensitive to dry weather and may account in part for the many failures to grow it successfully. Nearly all the other species of the genus have strong and abundant roots, even in the seedling stages. It therefore seems likely that the mangosteen will thrive better and under more widely varying soil and atmospheric conditions if the young plant is inarched to some species of the genus which has a good root system.

### PROPAGATION BY THE ORDINARY METHOD OF INARCHING.

When the ordinary method of grafting is employed or when mature branches of the mangosteen are inarched to stocks of some of the large-leaved species of Garcinia, unions are obtained which appear quite firm and evidently successful, but the differences in texture between the woods of stock and scion are too great for good unions to be effected. The lateral shoots or small branches of young trees of the mangosteen 3 to 4 feet in height have been tried repeatedly; but the wood of the mangosteen growths does not attain that requisite hard consistency which we get in seedling Garcinias of other species, varying in size from a few inches to 1½ feet in height. The wood of these seedlings is comparatively hard and gives a rapid and satisfactory callus; the branches of larger mangosteen plants on the other hand are green and comparatively soft, and the inarches, after being gradually severed from the parent mangosteens, look fairly promising for a day or two, but notwithstanding the best of care they droop and shrivel. Further experiments with shoots of larger mangosteen plants are now in progress to ascertain the result of delaying the severance of the mangosteen shoots from the mother tree, ranging from a period of six weeks to one of three to six months. The sound appearance of some of the unions indicates that this method may be successful.

### CONDITION OF THE WOOD OF SEEDLING MANGOSTEENS.

The texture of the stems of the seedling mangosteens 3 to 4 months old is firmer than that of lateral branches of seedlings 3 to 4 feet high, and at the earlier stage is admirably adapted for inarching; in fact, when united to a strong-growing plant of any of the larger leaved species of Garcinia, the union is rapid and very satisfactory. Seedlings of the mangosteen with stems averaging one-sixth of an inch in diameter at the time of inarching have increased within three months to half an inch in diameter.

### STOCK PLANTS FOR THE MANGOSTEEN.

The mangosteen (*Garcinia mangostana*) belongs to the natural family Guttiferæ. The genus Garcinia is a large one, the Index Kewensis listing 228 species. Of these species about 20 have been tried in the inarching experiments; and while the mangosteen unites with all of them, only a few can be recommended as promising stock plants. Two other genera of the same family, Calophyllum and Platonia, have been tried. Two species of Calophyllum, *C. calaba* and *C. inophyllum*, are not satisfactory because the union between these and the mangosteen is imperfect. This is partly because the stems of the Calophyllums are softer than those of the

seedling mangosteen and partly because the growth made by the former as they become older is much more rapid. *Platonia insignis* (Pl. VI, fig. 2), on the other hand, so far as the experimental work has progressed, is a very promising stock from one to three years after germination, and if it will grow under the conditions suitable for the mangosteen, it may turn out to be the best stock of all those tried. The most promising species of Garcinia for use as stock plants for the mangosteen are *G. tinctoria* (fig. 13), *G. morella*, and *G.*

FIG. 13.—Mangosteen seedling inarched on *Garcinia tinctoria* with foliage of stock plant opposite and below the union. Height of seedling at time of inarching, about 10 inches.

*livingstonei*, in the order named, the last a native of Portuguese East Africa. The two first named are from the Malay Peninsula.

The list of species of Garcinia experimented with is as follows: *G. cornea*, *G. hanburyi*, *G. morella*, *G. tinctoria*, and *G. spicata*, from the Malay Peninsula; *G. binucao*, *G. cowa*, and *G. indica*, from India; *G. livingstonei*, from Portugese East Africa; *G. speciosa*, from Burma; *G. loureiri* and *G. sizygiifolia*, from Borneo; and *G. fusca*,

from Siam. It is quite possible that several other species of Garcinia may be even more valuable as stock plants, and also that some species of the related genera may prove desirable, but other material than that mentioned has not been available in the work. All the promising species ought to be tried whenever there is an opportunity. Some species of Garcinia lately found in the Philippine Islands would seem to be promising mangosteen stocks, especially those said to grow under widely varying conditions.

### GROWING SEEDLING STOCKS.

None of the species of Garcinia used as stocks are difficult to raise from seeds, provided they are fresh. They are easiest to germinate when sown in soil composed largely of partially decomposed leaves mixed with a little loam and rough-grained sand. They should be potted as soon as the first leaves are well developed. All the Garcinias with the exception of *G. mangostana* have magnificent root systems and they thrive under ordinary treatment in so far as soil watering and a considerable range of temperature are concerned.

It is an important point to have the stock plants in an active stage of growth when the union is in progress, though the seedling mangosteens may be inarched while apparently dormant. Although the unions when both stock and scion are in a resting stage are fairly satisfactory, the difference in growth is easily observable when the stock plants are in active growth. To secure this active growth the stocks should be allowed to become dormant; then, when they are given larger pots, good drainage, and soil composed of rotted leaves, at least one-half, and the rest fibrous loam containing a little rough-grained sand, together with some rough charcoal and crushed bone, they will under high temperature respond with vigorous growth. When inarched in this condition the union is always satisfactory.

All plants used as stocks have been from one to three years old. Within that period the age of the stocks seems to make little difference, especially when used as nurse stocks. Mangosteen seedlings seven months old united on nurse stocks of 3-year-old *Garcinia tinctoria* made very fine unions (Pl. VII), and within six months after the union some of the mangosteen stems were almost as thick as those of the stocks.

### PREPARING SEEDLINGS FOR INARCHING.

The propagation of seedling mangosteens for inarching on the stems of seedling stocks of other species of Garcinia (fig. 13) does not differ materially from that operation as described for seedlings of the mango (p. 15). The most important difference to be observed

is that the roots of the mangosteen need to be kept alive only long enough to give partial support to the seedling while the union is taking place. In the inarched mango the roots of the seedling are very carefully tended because they are to become the roots of the future mango tree. To insure sufficient moisture, place around the ball of the seedling fresh sphagnum moss mixed with twice the quantity of partly decayed leaves. Keep this material in position around the roots of the seedling with a piece of cloth which will absorb water readily. The seedling may be supported with a piece of $\frac{1}{8}$-inch galvanized-iron wire while the union is taking place.

### MAKING THE INARCH.

Place the stem of the seedling mangosteen close to that part of the stem of the stock where it is desired to make the union, then tie the root of the seedling inclosed in a piece of sacking to the stem of the stock plant with a strand of raffia. After making the tie, and before cutting the ends of the strand of raffia, put in the wire support and make secure with raffia. Cut a slice from the stem of the stock, going into the stem about one-third of its diameter. The length of the slice is regulated by the length of available stem in the seedling; 2 inches is desirable, but less will suffice. Next remove a piece of the stem of the seedling exactly opposite the cut in the stock, exercising extreme care in making one side of the cut on the scion fit evenly with one side of the cut on the stock. Pay no attention to the other edges of stock and scion, but bind firmly together and the operation is complete. If the inarching is performed in summer, and this seems the best time, make a puddle of adhesive clay, mixing it with some raw cotton which has been cut up fine with a pair of shears; apply this around the parts to be united and allow it to dry. The clay serves two purposes—it excludes air and it absorbs all the sap exuded from the cut portions. The raw cotton prevents the puddled clay from disintegrating while the union is taking place.

It is well that the point of union should be so chosen that a few leaves of the stock plant may be left growing below the union (fig. 13) after the top of the stock and the roots of the seedling have been removed. If the union is near the base of the stock and below the foliage the subsequent growth made by the inarched seedling mangosteen after being separated from its roots is not so rapid nor so robust as it is when placed farther up the stem and above a few of the leaves. When mangosteen seedlings are inarched on nurse stocks the conditions are different, and the union is made as low on the stock as possible (Pl. VI, fig. 2, *C*).

### REMOVING THE TOPS OF THE STOCKS AND THE ROOTS OF SEEDLING MANGOSTEENS AFTER A UNION HAS BEEN EFFECTED.

After the seedling mangosteens have become united with the stock plants the tops of the stocks should be gradually severed above the union. A notch may be made in the stem of the stock immediately above the union and on the side of the stem opposite to it. Ten days afterwards the top may be removed altogether.

When seedling mangosteens are inarched with the intention of removing the roots after the union is perfect, the soil around the roots, held in position by the piece of cloth, should be allowed only a small quantity of water for a period of about two weeks after the tops of the stocks have been removed, then the stem of the mangosteen seedling may be gradually severed immediately below the union. Any leaves on the stem of the stock plant below the top of the united parts (fig. 13) may be allowed to remain, as they are helpful in keeping the inarched seedling in a healthy condition till the time arrives when it will make large leaves of its own. But in the nurse-plant method it does not seem necessary to allow any of the leaves to remain on the stock.

### INARCHED MANGOSTEEN SEEDLINGS REESTABLISHING THEIR OWN ROOT SYSTEMS.

During the progress of the experiments in inarching the mangosteen several of the inarched plants exhibited a peculiar characteristic which up to that time had not been noticed in any other inarched plant. About eighteen months after 1-year-old mangosteen seedlings were apparently united to *Garcinia tinctoria*, as well as to other species, and long after the root and part of the stem of the mangosteen seedling, together with the top of the stock, had been severed and the mangosteen had made splendid growth, as evidenced by large, well-formed, and deep-green leaves, each suddenly developed a very thick aerial root at the base of the inarched stem of the mangosteen (Pl. VIII, fig. 2). This root became elongated and pierced the soil several inches below the point at which the roots first appeared, apparently making very rapid progress after reaching the soil. About two months afterwards the extra rapid growth of the new leaves was pronounced. In one or two instances the stock plants on which the mangosteens were inarched began to decay; the dissolution was rapid, and in a few months from the appearance of the aerial roots the rebellious mangosteens were again on their own roots, looking strong and healthy (Pl. VIII, fig. 1).

The behavior of the inarched seedlings in reestablishing their own root systems strongly suggests noncongeniality of the scion to the

stock; but that this is not true is proved by the behavior of those mangosteens propagated by the nurse-plant system. Moreover, it has been found that the stems of seedlings when inarched at a point 2 or 3 inches above the first pair of leaves on the stocks, as seen in figure 13, evidently make permanent unions; at least, there has been no attempt on the part of the scions to produce roots, and the stems of the stocks have increased considerably in girth since the unions took place. As further evidence that the formation of roots at the base of the inarched branch is not due to noncongeniality of stock to scion it may be mentioned that the bases of the inarched branches of litchi when inarched on seedlings of the same species form roots very freely. Especially when the branch is severed an inch or two from the lower part of the union, and the cut surface touches the soil, roots are always formed abundantly. It has been possible in numerous instances, after these roots have made considerable headway, to obtain a second plant as a result of this characteristic by severing the stem after rooting at a point as near the base of the inarched part as possible.

During the early part of 1909 the idea suggested itself that this peculiar feature in the behavior of inarched mangosteen plants described above might be used to bring the seedlings through the earlier and crucial stages of their existence. So far as our work has gone the results are exceedingly satisfactory, and the new method may be termed the nurse-plant system of propagation.

### THE NURSE-PLANT SYSTEM OF PROPAGATING THE MANGOSTEEN.

About thirty seedlings of the mangosteen, averaging 4 inches in height, were available for taking advantage of the lesson taught by the behavior of the inarched plants described above. All of these seedlings were beginning to show in their foliage signs of sickness. They were carefully removed from the 3-inch pots in which they had been growing, the soil was washed from the roots in tepid water, and each seedling was planted in a 6-inch pot containing a healthy 2-year-old plant of *Garcinia tinctoria*. Each mangosteen was planted as close to the nurse plant as possible without destroying its roots, so that inarching could be easily performed after the mangosteen showed signs of recovering from any slight setback resulting from its removal. The plants were placed in a humid atmosphere with the temperature ranging from 70° at night to 90° F. during the day. Three weeks after the seedlings were placed in the pots containing their prospective stocks they showed a slight improvement. They were then carefully inarched, and within six weeks the improved appearance of all the seedlings indicated that successful unions had taken place (fig. 14). The tops of the stock plants were then removed. The subsequent progress made by the mangosteens on nurse stocks

has been in many instances greater than that made by seedlings inarched by the ordinary method (Pl. VII). Several of these mangosteens worked by the nurse-plant method have been sent to the Canal Zone and are reported to be doing well. The remaining ones still in the greenhouse continue to make good growth, but the stems of the stock plants do not show as much increase in diameter as do those of the mangosteens attached to them (fig. 14).

In some instances the roots of the nurse plants show no appreciable cessation of growth after the tops of the plants have been removed. One would expect that in such event the roots of the inarched mangosteen seedlings would not be well developed, but as a matter of fact they are much superior to those of an uninarched seedling of the same age (Pl. VII), proving that as a result of the union the mangosteen is nursed along during the critical period of its existence in a

FIG. 14.—Group of mangosteen seedlings inarched by the nurse-plant method. The tops of the nurse plants have been removed.

most satisfactory way. This undoubtedly indicates that the mangosteen needs treatment of this nature to bring it through the early seedling stages, because the roots of the uninarched seedlings, especially within a year after germinating, are never robust, and too much or too little water produces bad effects. Those plants, however, which were inarched on other species of Garcinia by the seedling-inarch method seem to thrive well when subjected to the treatment usually accorded inarched mangos.

Although our experiments in inarching the mangosteen on nurse plants have turned out very satisfactorily, not a plant being lost, the method first used has been improved considerably, so that there is now less danger from careless work. The nurse plants of *Garcinia tinctoria* should be grown in small-sized pots, not larger

than 4 inches, previous to placing them in the 6-inch size. When getting their final shift the ball should be manipulated so that the stem of the seedling will be a little to one side so as to make room for an empty 3-inch pot to be placed in the soil beside the stock plant (Pl. VI, fig. 2, *A*). When the stock plant is established in the soil, after perhaps three or four weeks, that is, when the new roots have had time to develop, the empty 3-inch pot is removed (Pl. VI, fig. 1, *B*) and the root of a mangosteen taken from a pot of the same dimensions is placed in the empty space and the soil carefully but firmly rammed around it. Generous treatment will result in further development of the root action of both mangosteen and nurse stock. They are then inarched (Pl. VI, fig. 1, *C*), and when the union is satisfactory, which will be in about five weeks, the top part of the stock above the inarch may be gradually removed. The roots of both nurse plant and scion are left undisturbed because, if the stock dies, the root system of the seedling mangosteen will probably have become strong enough to sustain the plant by reason of the assistance given to it by the nurse plant during its precarious stage; and if, on the other hand, the roots of the seedling succumb, it probably will be due to the fact that the stock is supplying enough root action for the mangosteen.

### FUTURE STAGES OF GROWTH.

It should be distinctly understood that certainty of success with either method, in so far as it relates to the future stages of growth of the mangosteen, is by no means guaranteed when the plants are put in place in the open. All that it is intended to claim is that the method is a promising one on account of the rapid progress made by the seedlings after the union takes place. The seedlings which have been inarched have not as yet had time to make sufficient progress to demonstrate that they will grow rapidly on the stocks used; but it has been thought best to make public the discovery of this method as soon as possible, in order that experimenters may try it with a large number of different stocks. The mangosteen, however, is well known to be a rebellious subject; and beyond the union of its seedlings with older stocks of different species nothing has been accomplished.

### PACKING SEEDS FOR SHIPMENT.

It has been found that mangosteen seeds received in numerous shipments from various parts of tropical Asia do not retain their vitality for any considerable length of time, probably on account of unsuitable packing material or of improper packing. Most of the shipments have arrived without a trace of life in the seeds, a\

condition due to the packing material in the tin mailing tubes being too wet. Sometimes the seeds arrived in dampened moss and sawdust, mixed in equal parts. Other shipments were received packed in each of these materials, sometimes wet, at other times dry; but as yet we have never received a successful shipment when these materials were used, whether wet or dry. The best shipment came from Ceylon a few years ago, packed in comparatively dry, powdered charcoal. From that particular shipment nearly every seed sprouted. The charcoal when weighed immediately after the seeds were removed and again when sundried, showed a difference of less than half an ounce to the pound. It sometimes happens that the tin mailing tubes, frequently less than 2 inches in diameter, are so placed en route that they are subjected to high temperatures and the seeds are thus injured.

### PRELIMINARY TREATMENT AND SOWING OF THE SEEDS.

The seeds should be carefully looked after the moment they arrive. If any of them have made an effort to germinate en route while still in the charcoal, owing to some of the fleshy part of the fruit adhering to them when they were shipped, they should be handled with very great care, as the soft protruding parts are very susceptible to injury. Washing them in tepid water will partly remove some of the deleterious matter surrounding them. Before they become dry they should be dusted with powdered charcoal and immediately planted one at a time in a flat of leaf soil made quite firm. The germinating medium may be prepared beforehand when a shipment of seeds is expected. It should not be gathered promiscuously from the woods, as it is then liable to contain deleterious matter. Beech leaves about a year old, chopped very fine, with a small quantity of rough-grained sand and a little charcoal added, will give a very satisfactory germinating medium. When the seeds have begun to sprout en route, they should not be pressed into the material, but each one should be arranged with the sprouted part occupying a slight depression on the surface of the soil and covered with half an inch of the material. The leaf soil should be placed in a wooden flat and the top of the box covered with panes of glass, so that a humid atmosphere may be constantly maintained. The temperature of the greenhouse should range from 75° F. at night to much higher in the daytime and the seed box should be protected from direct sunlight.

The seedlings will thrive in the seed flat until they are about 2½ inches above the surface. They may then be potted off singly in 2½-inch or 3-inch pots, with good drainage. In potting, material should be used similar to that recommended for germination, with a very

small quantity of mellow loam added. Coconut fiber or even thoroughly rotted wood may be mixed with it, care being taken that it is free from deleterious fungi. If leaf soil is not available, coconut fiber is very good, but great care is necessary in watering, as the fiber holds water like a sponge. Thus a 5-inch pot will hold 6 ounces of dry fiber when firmly pressed down, but twenty-four hours after being saturated the fiber will weigh 19 ounces. It not only holds more water than most other substances, but it holds it longer, and it is this peculiarity which makes it one of the best media for germinating purposes, that is, provided the attendant is able to judge accurately of its water content.

FIG. 15.—Group of inarched litchi plants; also seedling litchi stocks prepared for inarching.

## PROPAGATING VARIETIES OF LITCHI BY THE SEEDLING-INARCH METHOD.

Plants of one of the finer varieties of litchi (*Litchi chinensis*) were obtained from China two years ago. They are said to be propagated in that country partly by layering and partly by notching large branches, and covering the wounds with a quantity of soil kept moist. When roots are at length produced, the branches are removed from the tree, trimmed, and put in receptacles until time for planting; but during the period of propagation the percentage of loss is said to be large. The propagation of these plants by the seedling-inarch method has been very successful (fig. 15). The Chinese, or litchi, nuts, as they are called (Pl. IX), offered for sale in the fruit stores of this country are dried previous to their importation and therefore are useless for the purpose of raising young plants. The Office of Foreign Seed and Plant Introduction of the Bureau of Plant Industry obtained a small consignment of untreated litchi seeds from China

about eighteen months ago, all of which germinated. The plants thus obtained proved to be the best stocks to use. Young branches of the improved variety of the litchi were inarched on these seedlings, every one making a very successful union. They were subsequently distributed. Many hundreds of plants could be propagated annually from the plants of this variety of the litchi now in the greenhouse if seedling litchi stocks were available for inarching. The next best stock is the longan (*Euphoria longan*), but while the unions are fairly successful on this species, they are slower than with the litchi stocks.

The litchi as a fruit-producing plant is at its best in China when grown in comparatively wet ground and in soil consisting largely of decomposed vegetable matter. It probably would succeed admirably in the Everglades of Florida in places where there is little likelihood of exposure to a temperature lower than 30° F. In California the tree does not look happy, but all of those recently seen by the writer were in dry, loamy soil. The Canal Zone and Porto Rico will probably prove congenial homes for this fruit tree. The fruits sent to the United States are not of the best varieties, being small, seldom more than an inch in diameter. The finer varieties are said to bear much larger fruit.

The method of propagation in its essential features is like that described for the mango (p. 14). The seedlings to be used as stocks are taken from 3-inch pots, the soil on the upper part of the ball removed, and a large handful of coconut fiber secured around the roots by wrapping in a piece of sacking about 8 inches square. These seedling stocks are fastened to the stout branches of the parent litchi or to stakes set in the soil of the pot. The branchlets are then inarched to the seedlings and tied with raffia, and the parts to be united are covered with clay. During the few weeks occupied in uniting, the roots of the seedlings make rapid headway in the coconut fiber. The unions are invariably good when seedlings of the same species are used. If the compound leaves on the scion are large it is advisable to trim them back slightly before severing the inarch from the parent tree. After severing, the inarched plants may be potted and placed in a close frame in the greenhouse, or they may be put in shallow boxes and the roots covered with coconut fiber, the atmosphere being kept moist. The sacking should not be removed, because, when the scions have united, the white roots of the seedlings will be found to have pierced the covering, so that to remove this sacking would necessarily injure the roots. The balls should be put in 5-inch or 6-inch pots, as may be necessary; the soil should consist mainly of decomposed leaves.

It is a peculiarity of the litchi that it makes several flushes or growths in a season; therefore, material for propagation is abundant

even in a small tree. Seedling stocks have been used when the stems were not over one-eighth of an inch in diameter and from that to one-fourth of an inch, the latter thickness giving the best results.

## PROPAGATING THE RAMBUTAN.

The rambutan (*Nephelium lappaceum*), said by some of the inhabitants of Java and elsewhere to produce a fruit even more delicious than that of the mangosteen, is amenable to rapid propagation if the young shoots are united to seedling stocks of the longan (*Euphoria longan*). It is thought that the Canal Zone will supply the necessary conditions for the successful cultivation of this tree. It is said that there are several varieties, and if it is possible to import vegetatively propagated plants of these varieties successfully, as was done with the litchi, their rapid multiplication in this country will be assured.

## SUMMARY.

It will be observed from the foregoing descriptions of the improved methods of propagating the mango, the mangosteen, and the litchi that practically the same method is employed with each; the uniting of a comparatively young seedling with a shoot of an approved variety of mango; the uniting of mangosteen seedlings with different species of the genus to which the mangosteen belongs, and even with species of different genera of the same family; and the uniting of shoots of approved varieties of litchi with seedling stocks or with seedlings of other species of the same genus.

Seedlings not more than a few months old are always used. The mango and litchi seedlings are used as stocks only, but the mangosteen seedlings are used as scions.

The operation with each kind of plant is a decided success. The method is so simple that it can be used by a person having no previous experience in the propagation of plants. It saves much of the time necessarily spent with the older methods. The worked plants are healthier and the operation is many times cheaper than the older methods.

# PLATES.

## DESCRIPTION OF PLATES.

PLATE I. Fig. 1.—Australian finger lime (*Citrus australasica*) inarched on lemon stock when a 5-weeks-old seedling; shown in text figures 5 and 6. In bearing only two years after the germination of the seed. The fruits are the result of cross-pollination with the so-called Panama orange. Fig. 2.—Crossed seedling of Australian finger lime and the Panama orange, grown from seed of fruit shown in figure 1. One of 13 seedlings showing hybrid characters in increased size of leaves and slightly winged and elongated petioles. This seedling was inarched three weeks after germination to a 2-year-old lemon stock. The top of the stock plant has been removed and the root of the seedling is ready to be severed. Time taken to form union, three weeks.

PLATE II.—Germination of mango. Seed with 8 sprouts, six weeks after planting. The two strongest sprouts should be selected for stocks and potted, the others discarded.

PLATE III. Fig. 1.—Mango seedling stock fastened to branch of tree of an approved variety, ready for inarching. The cuts in scion and stock are shown at *A* and *B*. Fig. 2.—Mango seedling with scion of approved variety tied in position. If conditions are favorable, a union will be effected in about thirty days.

PLATE IV. Fig. 1.—Inarched mango. The top of the seedling stock above the union has been gradually removed, and the shoot of the approved variety has also been gradually severed from the parent tree. Fig. 2.—Inarched mango in 5-inch pot. The sacking inclosing the roots is carefully removed unless the roots show outside the sacking, in which case the ball is placed in a 5-inch pot and fresh soil rammed firmly between the ball and side of the pot.

PLATE V. Fig. 1.—Mulgoba mango growing at Mangonia, Fla. This is the original tree of this variety introduced into Florida by the Department of Agriculture in 1889. This tree having numerous branches near the ground shows how easy it would be to inarch a very large number of shoots by the method here described. Fig. 2.—Bench of newly inarched mangos. After potting they are shaded from the sun and the atmosphere kept humid for a few days.

PLATE VI. Fig. 1.—Sickly mangosteen restored to health by inarching on *Garcinia tinctoria*. The original stem of the seedling, which had lost its upper leaves before being inarched, is shown at *A*. After the union took place both of the lateral shoots seen in the illustration developed and the top of the seedling died. The plant afterwards made fine growth. Fig. 2.—Inarching the mangosteen by the nurse-plant method, showing empty 3-inch pot inserted in soil when potting. Empty pot removed, leaving space for root of seedling from a 3-inch pot. Root of seedling mangosteen from 3-inch pot inserted in space provided for it and inarched to nurse stock plant of *Platonia insignis*.

PLATE VII. The nurse-plant system of propagating the mangosteen. The seedling was inarched to a plant of *Garcinia tinctoria* when the former was about 3 inches high and in a sickly condition. The roots of both stock and scion are developing satisfactorily. The plant represented was taken from a 6-inch pot.

PLATE VIII. Fig. 1.—Inarched mangosteen reestablishing its own root system. *A*, scar showing where it was inarched to a seedling of *Garcinia tinctoria; B*, point showing where the new root formed some time after the union took place previous to the rejection of the stock. Fig. 2.—Mangosteen developing a large root after it had been inarched to another species of Garcinia. The stock in this instance shows no signs of decay.

PLATE IX. Fruiting branch of litchi (*Litchi chinensis*). Two-thirds natural size.

FIG. 1.—CITRUS AUSTRALASICA, BEARING FRUIT TWO YEARS AFTER THE GERMINATION OF THE SEED.

FIG. 2.—CITRUS AUSTRALASICA × C. MITIS, GROWN FROM FRUIT SHOWN IN FIGURE 1.

MANGO SEED WITH EIGHT SPROUTS.

(One-half natural size.)

FIG. 1.—MANGO SEEDLING ATTACHED TO TREE, SHOWING CUTS IN STEMS OF SCION AND SEEDLING.

FIG. 2.—MANGO SEEDLING AND SCION IN PLACE.

FIG. 1.—INARCHED MANGO AFTER BEING SEVERED FROM PARENT TREE.

FIG. 2.—NEWLY INARCHED MANGO IN POT.

FIG. 1.—MULGOBA MANGO GROWING AT MANGONIA, FLA.

FIG. 2.—BENCH OF NEWLY INARCHED MANGOS.

FIG. 1.—SICKLY MANGOSTEEN RESTORED TO HEALTH BY INARCHING.

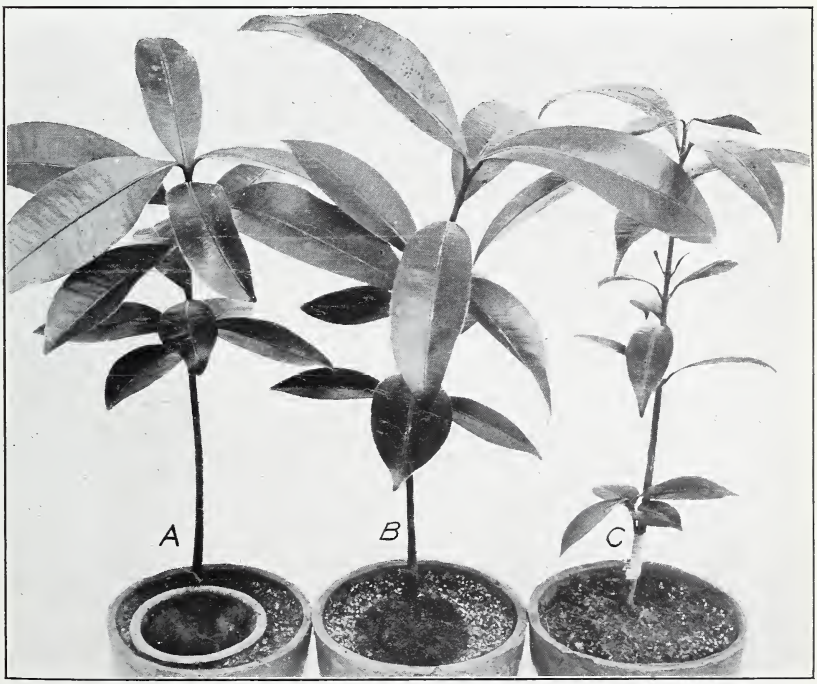



FIG. 2.—INARCHING THE MANGOSTEEN BY THE NURSE-PLANT METHOD.

MANGOSTEEN SEEDLING INARCHED TO GARCINIA TINCTORIA, NURSE PLANT.

(Much reduced.)

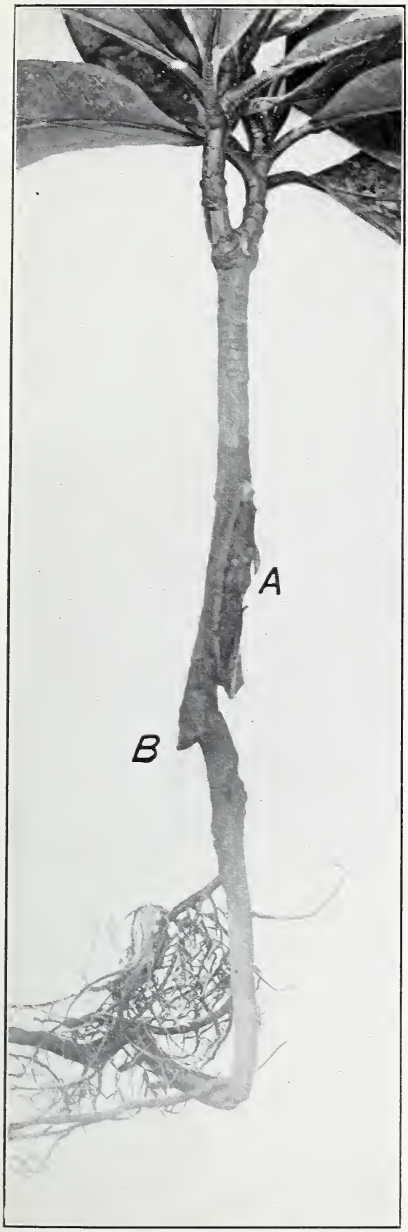
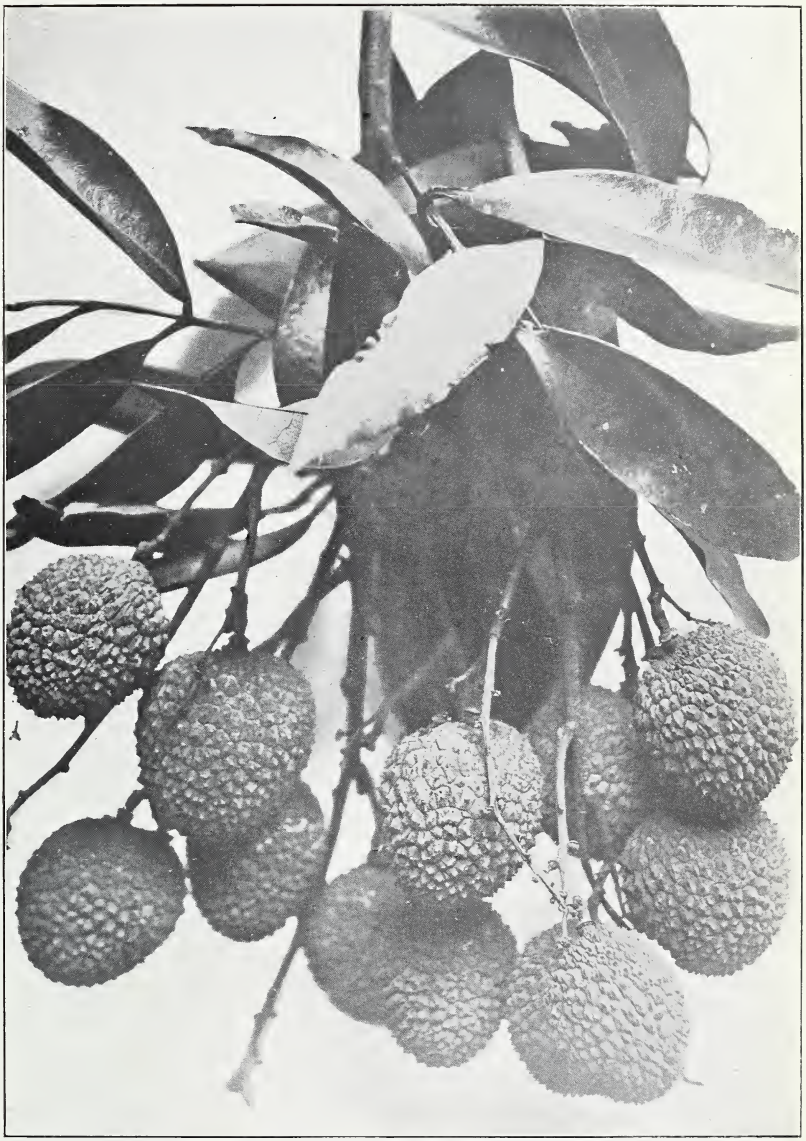



FIG. 1.—INARCHED MANGOSTEEN REESTABLISHING ITS OWN ROOT SYSTEM.

FIG. 2.—MANGOSTEEN DEVELOPING ROOT AFTER INARCHING.



FRUITING BRANCH OF THE LITCHI (LITCHI CHINENSIS).

(Two-thirds natural size.)

# INDEX.


Page.

Bed for sprouting mango seeds ..... 15
Budding, disadvantages of method of propagation ..... 10, 11
Burlap, use in process of inarching ..... 13, 16–17, 21, 23, 30, 31, 37, 40
Cacao, cost of propagation by inarching ..... 10
Calophyllum calaba, use as stock plant for the mangosteen ..... 27
inophyllum, use as stock plant for the mangosteen ..... 27
Canal Zone. *See* Mangosteen, experiments at Panama.
Charcoal, use in shipping and growing mangosteen seeds ..... 35
Citrus australasica. *See* Lime, finger.
Clay, use in process of inarching ..... 30, 37
Coconut, use of fiber in propagation processes ..... 17, 20, 36, 37
Euphoria longan, use as stock plant for the litchi and the rambutan ..... 37, 38
Finger lime. *See* Lime, finger.
Florida, methods used in propagating mangos ..... 18, 19, 40
seed yield of uncultivated mangos ..... 15
Garcinia binucao, use as stock plant for the mangosteen ..... 28
cornea, use as stock plant for the mangosteen ..... 28
cowa, use as stock plant for the mangosteen ..... 28
fusca, use as stock plant for the mangosteen ..... 28
hanburyi, use as stock plant for the mangosteen ..... 28
indica, use as stock plant for the mangosteen ..... 28
livingstonei, use as stock plant for the mangosteen ..... 28
loureiri, use as stock plant for the mangosteen ..... 28
mangostana. *See* Mangosteen.
morella, use as stock plant for the mangosteen ..... 28
sizygiifolia, use as stock plant for the mangosteen ..... 28
speciosa, use as stock plant for the mangosteen ..... 28
spicata, use as stock plant for the mangosteen ..... 28
tinctoria, use as stock plant for the mangosteen ..... 28, 29, 31, 32, 33, 40
Grafting, experience with mangosteen ..... 27
method of gaining abundant material ..... 14
Guttiferæ, genera furnishing promising stocks for the mangosteen ..... 27
Hammock soil. *See* Soil, hammock.
Harris, W., on methods of propagating the mangosteen ..... 24
Hybrids, propagation of cross of Panama orange and finger lime ..... 10, 40
Inarching, convenient placing of mother plants ..... 17–19
method of manipulation ..... 11, 16, 20, 21, 30, 37
Inclosure, lath, for mango trees to be propagated ..... 18, 20
Introduction to bulletin ..... 9–11
Jones, J., on the grafting of cacao ..... 10
Lath, use for inclosing mango trees for propagation ..... 18, 20
Lemon, use of seedlings as stocks ..... 10, 40
Lime, finger, propagation by the seedling-inarch method ..... 9–10, 13, 15, 40

Page.
Litchi, application of seedling-inarch method of propagation ..... 11, 32, 36–38, 40
soil and other requirements for successful growth ..... 37
chinensis. *See* Litchi.
Manetti, use as rose stocks ..... 9, 11
Mango, cost of propagation by inarching ..... 10
cultivation, delay caused by usual methods of propagation ..... 10–11
Mulgoba, original tree introduced into Florida ..... 40
propagation by the seedling-inarch method ..... 14–23, 38, 40
selecting and preparing the seeds ..... 14–15
soil for sprouting the seeds ..... 15
treatment before severing from parent tree ..... 21
varieties, testing in Florida ..... 22–23
Mangosteen, care of seedlings in pots ..... 26
difficulty in growing from seeds ..... 25–26
experiments at Panama ..... 24, 33
growing seedling stocks ..... 29
inarched, reestablishing its own root system ..... 31–32, 40
method of manipulation in propagation ..... 30, 40
plants used as stocks ..... 27–29
propagation by seedling-inarch and nurse-plant methods ..... 10, 11, 23–36, 38, 40
root system compared with other species of Garcinia ..... 26
temperature needed for germinating seeds ..... 35
treatment after union has been effected ..... 31, 34
Method, seedling-inarch, applicable to new plant introductions ..... 14
Moss, sphagnum, use in process of inarching ..... 17, 30
Nephelium lappaceum. *See* Rambutan.
Nurse-plant system of propagation. *See* Propagation by nurse-plant method.
Orange, Panama, propagation of hybrid on lemon stock ..... 10, 40
Panama Canal Zone. *See* Mangosteen, experiments at Panama.
orange. *See* Orange, Panama.
Philippines, source of promising mangosteen stocks ..... 29
Plants, stock, for mangosteen. *See* Mangosteen, plants used as stocks.
Plates, description ..... 40
Platonia insignis, use as stock for the mangosteen ..... 28, 40
Propagation by asexual methods ..... 9, 10–11, 23, 38
budding method ..... 10, 11, 14
grafting ..... 14, 27
nurse-plant method ..... 9–11, 30, 31, 32–34, 38, 40
seedling-inarch method ..... 9–11, 38, 40
Raffia, use in process of inarching ..... 30, 37
Rambutan, amenable to propagation by seedling-inarch method ..... 38
Rose, propagation by use of manetti stocks ..... 9, 11
Roots, aerial, development by inarched seedlings ..... 31–32, 40
Sacking cloth. *See* Burlap.
Scions, use in propagating the mangosteen ..... 24, 38, 40
Seedlings, age for use in propagation ..... 10, 27, 38
litchi, inarched, reestablishment of root systems ..... 32
mango, preparation previous to inarching ..... 16–17
mangosteen, care while growing in pots ..... 26
condition of the wood during growth ..... 27
inarched, reestablishment of root systems ..... 31–32, 40
preparation for inarching ..... 29–30

Page.
Seedlings, position when potted ..... 12, 16
preparation previous to inarching ..... 11–13, 16–17, 29–30, 40
rose, inarched on manetti stocks ..... 9, 11–13
treatment after unsuccessful attempt to inarch ..... 14
use as scions and as stocks in propagation ..... 24, 38, 40
Seeds, mango, selecting and preparing ..... 14–15
soil for sprouting ..... 15
mangosteen, germinating medium ..... 35
packing for shipment ..... 34–35
preliminary treatment and sowing ..... 35–36
Shipment by mail, sending of plants and seeds ..... 22, 34–35
Soil, hammock, use in process of inarching ..... 17, 21
medium for germinating mango seeds ..... 15
Staging for supporting plants during process of inarching ..... 11, 17, 20
Stocks, Garcinia, seedling, method of growing ..... 29
mango, growth of seedlings ..... 15–16
watering seedlings while uniting ..... 20
Summary of bulletin ..... 38
Time, saving accomplished by use of seedling-inarch and nurse-plant methods of propagation ..... 9, 10, 11, 23, 38
Woodrow, G. M., on methods of propagating the mangosteen ..... 24

202